

MULTILAYER GOLF BALL
WITH A THIN THERMOSET OUTER LAYER

5 This is a continuation-in-part of U.S. application No. 08/863,788, filed May 27, 1997, and a continuation-in-part of U.S. application No. 09/207,690, filed December 9, 1998, each of which is now pending

FIELD OF INVENTION

10 This invention relates generally to golf balls, and more specifically, to a multilayer golf ball. In particular, this invention relates to a golf ball having a core, an inner cover layer and a very thin outer cover layer, wherein the outer cover layer comprises a thermoset material formed from a castable, reactive liquid and the inner cover layer comprises a high flexural modulus material. The multilayer golf balls of the present invention provide "progressive performance" characteristics when struck with golf clubs of
15 varying head speed and loft angle.

BACKGROUND OF THE INVENTION

20 Until recently golf balls were typically divided into two general types or groups: 1) two piece balls and 2) wound balls (also know as three piece balls). The difference in play characteristics resulting from these different types of constructions can be quite significant.

25 Balls having a two piece construction are generally most popular with the recreational golfer because they provide a very durable ball while also providing maximum distance. Two piece balls are made with a single solid core, usually formed of a crosslinked rubber, which is encased by a cover material. Typically the solid core is made of polybutadiene which is chemically crosslinked with zinc diacrylate and/or similar crosslinking agents. The cover comprises tough, cut-proof blends of one or more materials known as ionomers such as SURLYNs®, which are resins sold commercially by DuPont or Iotek® which is sold commercially by Exxon.

30 The combination of the above-described core and cover materials provides a "hard" covered ball that is resistant to cutting and other damage caused by striking the ball with a golf club. Further, such a combination imparts a high initial velocity to the ball which results in increased distance. Due to their hardness however, these balls have a

relatively low spin rate which makes them difficult to control, particularly on shorter approach shots. As such, these types of balls are generally considered to be "distance" balls. Because these materials are very rigid, many two piece balls have a hard "feel" when struck with a club. Softer cover materials such as balata and softer ionomers in some instances, have been employed in two piece construction balls in order to provide improved "feel" and increased spin rates.

Wound balls typically have either a solid rubber or liquid filled center around which many yards of a stretched elastic thread or yarn are wound to form a core. The wound core is then covered with a durable cover material such as a SURLYN® or similar material or a softer cover such as balata. Wound balls are generally softer than two piece balls and provide more spin, which enables a skilled golfer to have more control over the ball's flight. In particular, it is desirable that a golfer be able to impart back spin to a golf ball for purposes of controlling its flight and controlling the action of the ball upon landing on the ground. For example, substantial back spin will make the ball stop once it strikes the landing surface instead of bounding forward. The ability to impart back spin onto a golf ball is related to the extent to which the golf ball cover deforms when it is struck with a golf club. Because wound balls are traditionally more deformable than conventional two piece balls, it is easier to impart spin to wound balls. However, wound higher spinning balls typically travel a shorter distance when struck as compared to a two piece ball. Moreover, as a result of their more complex structure, wound balls generally require a longer time to manufacture and are more expensive to produce than a two piece ball.

The United States Golf Association (USGA) has instituted a rule that prohibits the competitive use in any USGA sanctioned event of a golf ball that can achieve an initial velocity of greater than 76.2 meters per second (m/s), or 250 ft/s, when struck by a USGA velocity testing machine driver with a velocity of 43.76 m/s, *i.e.*, 143.8 ft/s (referred to hereinafter as "the USGA test"). However, an allowed tolerance of two percent permits manufacturers to produce golf balls that achieve an initial velocity of 77.7 m/s (255 ft/s).

Regardless of the form of the ball, players generally seek a golf ball that delivers maximum distance, which requires a high initial velocity upon impact. Therefore, in an effort to meet the demands of the marketplace, manufacturers strive to produce golf

balls with initial velocities in the USGA test that approximate the USGA maximum of 77.7 m/s or 255 ft/s as closely as possible.

Therefore, golf ball manufacturers are continually searching for new ways in which to provide golf balls that deliver the maximum performance in terms of both distance and spin rate for golfers of all skill levels.

Relatively recently, a number of golf ball manufacturers have introduced multilayer golf balls, *i.e.*, having multiple core intermediate mantle or outer core layer and/or cover layers, in an effort to overcome some of the undesirable aspects of conventional two piece balls, such as their hard feel, while maintaining the positive attributes of these golf balls (including their increased initial velocity and distance). Examples of multilayer balls include the Altus Newing (Bridgestone), Reygrande 2x2, Giga (Spalding), Strata (Spalding), Metal Mix (Dunlop), and Ultra Tour Balata (Wilson).

Additionally, a number of patents have been issued directed towards modifying the properties of a conventional two piece ball by altering the typical single layer core and/or single cover layer construction to provide a multilayer core and/or cover. The inventions disclosed in these patents are directed towards improving a variety of golf ball characteristics.

For example, there are a number of multilayer ball patents directed towards improving the spin, click or feel of solid balls while maintaining the distance provided by the solid construction. A variety of approaches to manipulating the core construction are described in the art. For example, U.S. Patent No. 5,072,944 discloses a three-piece solid golf ball having a center and outer layer which are prepared from a rubber composition, preferably having a base rubber of polybutadiene. This patent teaches that it is desirable that the center core is softer than the outer layer, wherein the layers have a hardness (Shore C) of 25-50 and 70-90 respectively.

U.S. Patent No. 4,625,964 relates to a solid golf ball having a polybutadiene rubber core of a diameter not more than 32mm, and a polybutadiene rubber intermediate layer having a specific gravity lower than that of the core material.

U.S. Patent No. 4,848,770 discloses a non-wound three-piece golf ball which includes a core of a highly filled synthetic rubber or polymeric material, an intermediate mantle or outer core layer of an unfilled synthetic rubber and a cover. The core and intermediate mantle or outer core layer have a hardness between 50-95.

U.S. Patent No. 5,002,281 is directed towards a three-piece solid golf ball which has an inner core having a hardness of 25-70 (Shore C) and an outer shell having a hardness of 80-95 (Shore C), wherein the specific gravity of the inner core must be greater than 1.0, but less than or equal to that of the outer shell, which must be less than 1.3.

5 U.S. Patent No. 5,253,871 concerns a golf ball having a three piece structure comprising an elastomer core, an intermediate layer of a thermoplastic material containing at least 10% of ether block copolymer, preferably blended with an ionomer and a thermoplastic cover.

10 Several additional patents are directed to golf balls having multiple cover layers. For example U.S. Patent No. 4,431,193 relates to a golf ball having a multilayer cover wherein the inner layer is a hard, high flexural modulus ionomer resin and the outer layer is a soft, low flexural modulus ionomer resin, wherein either or both layers may comprise a foamed ionomer resin.

15 U.S. Patent No. 5,314,187 also relates to golf balls having a cover formed with multiple layers, wherein the outer layer is molded over the inner layer and comprises a blend of balata and an elastomer and the inner layer is an ionomer resin.

20 U.S. Patent No. 4,919,434 is directed towards a golf ball having a cover which comprises an inner layer and an outer layer each of which comprise a thermoplastic resin, preferably the layers comprise of materials that are capable of fusion bonding with each other.

25 UK Patent Application Nos. GB 2,291,817 and 2,291,812 are both directed towards a wound golf ball with improved distance comprising a dual cover layer, wherein the inner cover layer has a high hardness as compared to the outer cover layer. These references teach that the cover layers may be formed from balata or ionomer resins and should have a combined thickness of less than 4 mm.

30 UK Patent Application No. GB 2,278,609 discloses a multilayer golf ball providing enhanced distance without sacrificing playability or durability comprising a core, an inner cover layer and an outer cover layer wherein the inner cover layer comprises a high acid ionomer and the outer cover layer comprises a soft ionomer or a non-ionomeric thermoplastic elastomer.

However, none of these patents disclose a multilayer ball having a very thin thermoset outer layer formed from a castable reactive liquid as disclosed herein to provide

golf balls exhibiting a "progressive performance" such as those golf balls of the present invention.

SUMMARY OF THE INVENTION

5 The present invention is directed towards a multilayer golf ball which provides "progressive performance" characteristics when struck with golf clubs of varying head speeds and loft angles.

 The present invention is further directed towards a multilayer golf ball which in general comprises a core, an inner cover layer and a very thin (*i.e.*, <0.05") outer cover
10 layer.

 In one embodiment, the multilayer golf ball includes a core having a solid center made from a first rubber based material and solid outer core layer made from a second rubber based material having different physical properties from the first rubber based material. The cover of the ball includes an inner cover layer and an outer cover layer.
15 The inner cover layer is made from an ionomer material having a first shore D hardness and having an outer diameter of at least 1.6 inches. The outer cover layer is made from a thermoset material having a second shore D hardness less than the first.

 In another embodiment, the outer cover layer has a hardness from about 30 shore D to about 60 shore D. In another embodiment, the outer cover layer of the ball has a
20 hardness from about 40 shore to about 60 shore D. In yet another embodiment, the outer cover layer has a hardness from about 50 shore D to about 60 shore D.

 In one embodiment, the inner cover layer of the golf ball has a flexural modulus of about 65,000 psi or more. In another embodiment, the inner cover layer has a hardness from about 65 shore D to about 74 shore D. In yet another embodiment, the inner
25 cover layer of the golf ball has a hardness from about 68 shore D to about 72 shore D. In another embodiment, the outer diameter of the inner cover layer is from about 1.6 inches to about 1.63 inches. In yet another embodiment, the outer diameter of the inner cover layer is from about 1.62 inches to about 1.63 inches. In another embodiment, the center of the ball has an outer diameter from about 0.75 inches to about 1.3 inches. In yet another
30 embodiment, the center of the ball has an outer diameter from about 1 inch to about 1.15 inches.

In one embodiment, the outer diameter of the outer core layer is from about 1.55 inches to about 1.58 inches. In another embodiment, the outer core layer has a first crosslinking agent in an amount from about 20 to about 40 parts per hundred of rubber. In another embodiment, the amount of first crosslinking agent in the core outer layer is from about 30 to about 38 parts per hundred of rubber. In yet another embodiment, the outer core layer has from about 10 to about 17 parts of balata per hundred parts of rubber.

In another embodiment, the center of the ball has a second crosslinking agent in an amount from about 15 to about 25 parts per hundred of rubber. In another embodiment, the amount of second crosslinking agent in the center is from about 19 to about 25 parts per hundred of rubber.

The invention further relates to a multilayer golf ball having a core including a solid center made from a first rubber based material and a solid outer core layer made from a second rubber based material having different physical properties from said first rubber based material. The cover of the ball includes an inner cover layer made from a material having a first shore D hardness from about 65 shore D to about 74 shore D and having an outer diameter of at least 1.6 inches, and further includes an outer cover layer made from a thermoset material having a second shore D hardness less than the first. In another embodiment, the outer cover layer has a hardness of from about 30 shore D to about 60 shore D. In yet another embodiment, the inner cover layer material has a hardness from about 68 shore D to about 72 shore D. In another embodiment, the outer cover layer has a hardness from about 40 shore D to about 60 shore D. In yet another embodiment, the hardness of the outer cover layer is from about 50 shore D to about 60 shore D.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-section of a golf ball 2 having a core 4, an inner cover layer 6 and an outer cover layer 8.

DETAILED DESCRIPTION OF THE INVENTION

By the present invention, it has been discovered that a golf ball of the presently claimed construction has a "progressive performance" when struck with a variety of clubs. More specifically, as used herein, the term "progressive performance" means that the presently claimed golf ball has the distance benefits of a traditional hard covered two piece ball when struck with a club having a high club head speed and a low loft angle, but

also the high spin and feel characteristics similar to that of a traditional soft covered wound ball when struck with a club having a low head speed and high loft angle. Thus, golf balls of the presently claimed construction provide the "best of both worlds" in the golf ball art, *i.e.*, a maximum distance ball for long shots (*e.g.*, with a driver or long iron) which has high spin and controllability for short shots (*e.g.*, with a wedge).

Without being limited to any particular theory, it is believed that with low club head speed and high loft shots such as those made with an 8-iron or a wedge, a ball's surface hardness has a greater influence on the ball's flight characteristics than the ball's overall construction. Thus, all other parameters being equal, a ball with a softer surface will have a higher spin rate than one with a harder surface, regardless of the ball's overall construction. Conversely, however, when a golf ball is struck with a high club head speed and a low loft angle, such as that of a driver, it appears that the opposite is true and that the overall construction of the ball has a greater influence on the ball's flight characteristics than does the surface hardness. For such high club head speed, low loft angle shots, *i.e.* full shots, it is desirable for the ball to have a low spin rate in order to achieve maximum distance.

A multi-layered core construction facilitates the ability to modify a ball's moment of inertia through the manipulation of the specific gravity of each individual core layer. By using a multi-layered core construction, a ball designer is able to control a ball's spin performance when hit with full shots. With full shots, the ball's inner construction greatly affects the ball's spin rate. Thus, the spin rate of driver and long iron shots can be controlled more precisely through use of multi-layer core technology. Further, the ball's feel can be influenced with greater control than can be achieved from a single solid core construction by modifying the hardness or compressibility of the individual layers.

Accordingly, by the present invention, it has been found that by creating a golf ball with a low spin construction, but adding a very thin layer of a relatively soft thermoset material formed from a castable reactive liquid, a golf ball with "progressive performance" from driver to wedge can be formed. As used herein, the term "thermoset" material refers to an irreversible, solid polymer that is the product of the reaction of two or more prepolymer precursor materials.

The invention is particularly directed towards a multilayer golf ball which comprises a core, an inner cover layer and an outer cover layer. The thickness of the outer

cover layer is critical to the "progressive performance" of the golf balls of the present invention. If the outer cover layer is too thick, this cover layer will contribute to the in-flight characteristics related to the overall construction of the ball and not the cover surface properties. However, if the outer cover layer is too thin, it will not be durable enough to withstand repeated impacts by the golfer's clubs. Specifically, it has been determined that the outer cover layer must have a thickness of less than about 0.05 inches, preferably between about 0.02 and about 0.04 inches. Most preferably, this thickness is about 0.03 inches.

The outer cover layer is formed from a relatively soft thermoset material in order to replicate the soft feel and high spin play characteristics of a balata ball when the balls of the present invention are used for pitch and other "short game" shots. In particular, the outer cover layer should have a Shore D hardness of from about 30 to about 60, preferably 35-50 and most preferably 40-45. Additionally, the materials of the outer cover layer must have a degree of abrasion resistance in order to be suitable for use as a golf ball cover.

The outer cover layer of the present invention can comprise any suitable thermoset material which is formed from a castable reactive liquid material. The preferred materials for the outer cover layer include, but are not limited to, thermoset urethanes and polyurethanes, thermoset urethane ionomers and thermoset urethane epoxies. Examples of suitable polyurethane ionomers are disclosed in co-pending U.S. Patent Application No. 08/482,519, filed June 7, 1995, entitled "Golf Ball Covers", the disclosure of which is hereby incorporated by reference in its entirety in the present application.

Thermoset polyurethanes and urethanes are particularly preferred for the outer cover layers of the balls of the present invention. Polyurethane is a product of a reaction between a polyurethane prepolymer and a curing agent. The polyurethane prepolymer is a product formed by a reaction between a polyol and a diisocyanate. The curing agent is typically either a diamine or glycol. Often a catalyst is employed to promote the reaction between the curing agent and the polyurethane prepolymer.

Conventionally, thermoset polyurethanes are prepared using a diisocyanate, such as 2,4-toluene diisocyanate (TDI) or methylenebis-(4-cyclohexyl isocyanate) (HMDI) and a polyol which is cured with a polyamine, such as methylenedianiline (MDA), or a trifunctional glycol, such as trimethylol propane, or tetrafunctional glycol, such as

N,N,N',N'-tetrakis(2-hydroxypropyl)ethylenediamine. However, the present invention is not limited to just these specific types of thermoset polyurethanes. Quite to the contrary, any suitable thermoset polyurethane may be employed to form the outer cover layer of the present invention.

5 The inner cover layer of the present invention is preferably formed from a hard, high flexural modulus, resilient material which contributes to the low spin, distance characteristics of the presently claimed balls when they are struck for long shots (*e.g.* driver or long irons). Specifically, the inner cover layer materials have a Shore D hardness of about 65-80, preferably about 68-74, and most preferably about 70-72. Furthermore, as
10 defined herein, the term "high flexural modulus" means a flexural modulus (as measured by ASTM 790) of at least about 65,000 psi, preferably about 70,000 psi to about 120,000 psi and most preferably at least about 75,000 psi. The thickness of the inner cover layer can range from about 0.020 inches to about 0.045 inches, preferably about 0.030 inches to about 0.040 inches and most preferably about 0.035 inches.

15 The inner cover layer may be formed from a wide variety of resilient materials. Among the preferred inner cover materials are hard, high flexural modulus ionomer resins and blends thereof. These ionomers are obtained by providing a cross metallic bond to polymers of monoolefin with at least one member selected from the group consisting of unsaturated mono- or di-carboxylic acids having 3 to 12 carbon atoms and
20 esters thereof (the polymer contains 1 to 50% by weight of the unsaturated mono- or di-carboxylic acid and/or ester thereof). More particularly, such acid-containing ethylene copolymer ionomer component includes E/X/Y copolymers where E is ethylene, X is a softening comonomer such as acrylate or methacrylate present in 0-50 (preferably 0-25, most preferably 0-20), weight percent of the polymer, and Y is acrylic or methacrylic acid
25 present in 5-35 (preferably at least about 16, more preferably at least about 16-35, most preferably at least about 16-20) weight percent of the polymer, wherein the acid moiety is neutralized 1-90% (preferably at least 40%, most preferably at least about 60%) to form an ionomer by a cation such as lithium*, sodium*, potassium, magnesium*, calcium, barium, lead, tin, zinc* or aluminum (*=preferred), or a combination of such cations. Specific acid-
30 containing ethylene copolymers include ethylene/acrylic acid, ethylene/methacrylic acid, ethylene/acrylic acid/n-butyl acrylate, ethylene/methacrylic acid/n-butyl acrylate, ethylene/methacrylic acid/iso-butyl acrylate, ethylene/acrylic acid/iso-butyl acrylate,

ethylene/methacrylic acid/n-butyl methacrylate, ethylene/acrylic acid/methyl methacrylate, ethylene/acrylic acid/methyl acrylate, ethylene/methacrylic acid/methyl acrylate, ethylene/methacrylic acid/methyl methacrylate, and ethylene/acrylic acid/n-butyl methacrylate. Preferred acid-containing ethylene copolymers include ethylene/methacrylic acid, ethylene/acrylic acid, ethylene/methacrylic acid/n-butyl acrylate, ethylene/acrylic acid/n-butyl acrylate, ethylene/methacrylic acid/methyl acrylate and ethylene/acrylic acid/methyl acrylate copolymers. The most preferred acid-containing ethylene copolymers are ethylene/methacrylic acid, ethylene/acrylic acid, ethylene/(meth)acrylic acid/n-butyl acrylate, ethylene/(meth)acrylic acid/ethyl acrylate, and ethylene/(meth)acrylic acid/methyl acrylate copolymers. Additional ionomers are described in Application Nos. 09/086,263, 08/996,403 and 08/786,618, all of which are incorporated by reference in their entirety.

The manner in which the ionomers are made is well known in the art as described in *e.g.*, U.S. Patent No. 3,262,272. Such ionomer resins are commercially available from DuPont Co. under the tradename SURLYN® and from Exxon under the tradename Iotek®. Some particularly suitable SURLYNS® include SURLYN® 8140 (Na) and SURLYN® 8546 (Li) which have an methacrylic acid content of about 19%.

However, the materials for the inner cover layer are not limited to ionomer resins. Instead, the present invention contemplates that virtually any resilient material which is compatible with the other materials of the golf ball may be employed as the inner cover layer. Examples of other suitable inner cover materials include thermoplastic or thermoset polyurethanes, thermoplastic or thermoset polyetheresters or polyetheramides, thermoplastic or thermoset polyester, a dynamically vulcanized elastomer, a functionalized styrene-butadiene elastomer, a metallocene catalyzed polymer or blends thereof.

Suitable thermoplastic polyetheresters include materials which are commercially available from DuPont under the tradename Hytrel®. Suitable thermoplastic polyetheramides include materials which are available from Elf-Atochem under the tradename Pebax®. Other suitable materials for the inner cover layer include nylon and acrylonitrile-butadiene-styrene copolymer (ABS).

The golf ball cores of the present invention may comprise any of a variety of constructions. For example, the core of the golf ball may comprise a conventional center surrounded by an intermediate mantle or outer core layer disposed between the center and the inner cover layer. The core may be a single layer or may comprise a plurality of layers.

The innermost portion of the core may be solid or it may be a liquid filled sphere. As with the core, the intermediate mantle or outer core layer may also comprise a plurality of layers. The core may also comprise a solid or liquid filled center around which many yards of a stretched elastic thread or yarn are wound.

5 One embodiment of the present invention relates to a multi-layer golf ball having a solid center surrounded by at least one additional solid outer core layer having a resilient rubber based component and a crosslinking agent present in an amount from about 20 to about 40 parts per hundred of polymer, preferably having an amount of crosslinking agent from about 30 to about 38 parts per hundred of rubber and most preferably having
10 about 37 parts crosslinking agent per hundred of rubber. It should be understood that the term "parts per hundred" is with reference to the rubber by weight.

 The center of the ball is preferably solid having a resilient rubber component and a crosslinking agent present in an amount from about 15 to about 25 parts per hundred of the rubber, preferably in an amount from about 19 to about 25 parts per hundred of the
15 rubber and most preferably having about 20 parts crosslinking agent per hundred of rubber.

 The materials for solid cores include compositions having a base rubber, a crosslinking agent, a filler, and a co-crosslinking or initiator agent. The base rubber typically includes natural or synthetic rubbers. A preferred base rubber is 1,4-polybutadiene having a cis-structure of at least 40%. If desired, the polybutadiene can also be mixed with
20 other elastomers known in the art such as natural rubber, polyisoprene rubber and/or styrene-butadiene rubber in order to modify the properties of the core.

 The crosslinking agent includes a metal salt of an unsaturated fatty acid such as a zinc salt or a magnesium salt of an unsaturated fatty acid having 3 to 8 carbon atoms such as acrylic or methacrylic acid. Suitable cross linking agents include metal salt
25 diacrylates, dimethacrylates and monomethacrylates wherein the metal is magnesium, calcium, zinc, aluminum, sodium, lithium or nickel.

 The initiator agent can be any known polymerization initiator which decomposes during the cure cycle. Suitable initiators include peroxide compounds such as dicumyl peroxide, 1,1-di(t-butylperoxy) 3,3,5-trimethyl cyclohexane, a-a bis (t-butylperoxy)
30 diisopropylbenzene, 2,5-dimethyl-2,5 di(t-butylperoxy) hexane or di-t-butyl peroxide and mixtures thereof.

Conventional prior art golf balls typically incorporate 5 to 50 pph of zinc oxide in a diacrylate-peroxide core system. However, the zinc oxide may be replaced by calcium oxide in a diacrylate-peroxide system to provide a suitable core composition.

As used herein, the term "filler" includes any compound or composition that
5 can be used to vary the density and other properties of the core. Fillers typically includes materials such as zinc oxide, barium sulfate, silica, calcium carbonate, zinc carbonate reground (recycled core material ground to 30 mesh particle) and the like.

In one embodiment of the present invention, the core comprises a center which is liquid-filled or solid around which an elastic thread is wound. The solid center is
10 typically a homogenous mass of a resilient material such as polybutadiene or a natural rubber. The liquid-filled center is typically a thin walled sphere made from a thermoplastic or thermoset material into which a liquid such as corn syrup is injected by means of a needle. The sphere is then sealed and typically frozen to make the core a solid mass. The windings for either type of center are provided by an elastic thread which is stretched and
15 wound about the core to a desired thickness.

The overall outer diameter (OD) of the core (including the center and any intermediate mantle layer(s), the outer core layer or windings) together with the inner cover layer of the golf balls of the present invention is about 1.58 inches to about 1.64 inches, preferably about 1.60 inches to about 1.63 inches, more preferably about 1.62 inches to
20 about 1.63 inches and most preferably about 1.62 inches. The outer diameter of the center of the core is about 0.75 inches to about 1.3 inches, preferably about 1 inch to about 1.15 inches. In another embodiment, the outer diameter of the core (including the center and any intermediate mantle layer(s) or windings) without the inner cover layer is about 1.5 inches to about 1.6 inches, preferably about 1.55 inches to about 1.58 inches.

The present multilayer golf ball can have an overall diameter of any size.
25 Although the United States Golf Association (USGA) specifications limit the minimum size of a competition golf ball to more than 1.680 inches in diameter, there is no specification as to the maximum diameter. Moreover, golf balls of any size can be used for recreational play. The preferred diameter of the present golf balls is from about 1.680 inches to about
30 1.800 inches. The more preferred diameter is from about 1.680 inches to about 1.760 inches. The most preferred diameter is about 1.680 inches to about 1.740 inches.

The cores and inner cover of the golf balls of the present invention can be made by any conventional process employed in the golf ball art. For example, the solid centers can be either injection or compression molded. Similarly, the wound centers employed in the present invention can be produced through conventional means. The inner cover layer and any mantle or outer core layer(s) are subsequently injection or compression molded about the core.

However, due to the very thin nature (less than 0.05"), it is not practical to form the outer cover layers of the ball of the present invention using conventional injection or compression molding techniques ordinarily employed in the golf ball art for applying cover materials. These conventional ball molding processes are not capable of easily applying such thin outer cover layers over a solid spherical surface.

Accordingly, it has been found by the present invention that the use of a castable, reactive material which is applied in a fluid form makes it possible to obtain very thin outer cover layers on golf balls. Specifically, it has been found that castable, reactive liquids which react to form a thermoset material provide desirable very thin outer cover layers.

The castable, reactive liquid employed to form the thermoset material can be applied over the inner core using a variety of application techniques such as spraying, dipping, spin coating or flow coating methods which are well known in the art. An example of a suitable coating technique is that which is disclosed in U.S. Patent Number 5,733,428, filed May 2, 1995 entitled "Method And Apparatus For Forming Polyurethane Cover On A Golf Ball", the disclosure of which is hereby incorporated by reference in its entirety in the present application. Similarly, United States Patent No. 5,006,297 to Brown et al. and United States Patent No. 5,334,673 to Wu both also disclose suitable coating techniques which may be utilized to apply the castable reactive liquids employed in the present invention. The disclosures of these patents are hereby incorporated by reference in their entirety. However, the method of the invention is not limited to the use of these techniques.

The following example of multilayer golf balls formed according to the present invention is given to illustrate the present invention. However, it is to be understood that the example is for illustrative purposes only and in no manner is the present invention limited to the specific disclosures therein.

EXAMPLES

The following examples are provided only for the purpose of illustrating the invention and are not to be construed as limiting the invention in any manner.

EXAMPLE 1

5 Golf balls of the present invention can be manufactured as follows. The core may be made using either a conventional wound core construction or a conventional two-piece core construction formed using methods well known in the art. The wound core construction can be either a solid rubber-based center or a liquid filled center around which
10 a length of elastic thread is wound. A conventional two-piece construction preferably comprises a *cis* 1,4 polybutadiene rubber that has been crosslinked with a metal salt of an unsaturated fatty acid such as zinc diacrylate.

These core constructions are then covered using a conventional compression molding technique with an inner cover layer of an ionomer having a methacrylic acid
15 content of at least about 16 weight percent (preferably SURLYN 8140 or SURLYN 8546).

The outer cover layer can be formed following the processes set forth in U.S. Patent No. 5,006,297 and U.S. Patent No. 5,334,673. A particularly desired material for forming the outer cover layer is 40D castable urethane.

It is believed that golf balls made in accordance with the present invention
20 will exhibit an appreciably lower spin rate when struck with a driver (and thus a greater overall distance) as compared to conventional "high performance" golf balls (*e.g.* Tour Balata [Titleist]), but have very similar or even higher spin rates when struck with an 8 iron and/or a "50 yard" wedge, thereby evidencing a "progressive performance" from driver to wedge in the golf balls of the present invention.

25 While it is apparent that the illustrative embodiments of the invention herein discloses fulfills the objective stated above, it will be appreciated that numerous modifications and other embodiments may be devised by those skilled in the art. Therefore, it will be understood that the appended claims are intended to cover all such modifications and embodiments which come within the spirit and scope of the present invention.

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EXAMPLES 2-8

Sample golf balls having multi-layered cores and thin thermoset outer covers were made and tested to determine the effects of the following eight construction variables on the balls' physical and performance properties:

Construction Variable	Low	High
Dual core Center Diameter (in.)	1	1.13
Center Hardness (parts of crosslinking agent per hundred parts rubber)	19	25
Outer Core Layer Diameter (in.)	1.55	1.57
Outer Cover Hardness (Shore D)	50	60
Inner Cover Diameter (in.)	1.62	1.63
Outer Core Layer Balata Level (parts per hundred of rubber)	10	17
Inner cover Hardness (Shore D)	68	72
Outer Core Layer Hardness (parts of crosslinking agent per hundred parts of rubber)	30	38

Seven groups of balls within the parameters listed above, and having ball weights similar to the weights of commercially available balls used for performance comparisons, were selected for spin testing. Physical properties of these seven ball groups are listed below:

Test Group	Center Diameter (in.)	Center Hardness (shore D)	Outer Core Layer Diameter (in.)	Outer Core Layer Hardness (shore D)	Outer Core Layer Balata Level (parts per hundred of rubber)	Inner Cover Diameter (in.)	Inner Cover Hardness (Shore D)	Outer Cover Hardness (shore D)
1	1	19	1.55	38	17	1.63	68	60
2	1	25	1.55	30	17	1.62	72	60
3	1	25	1.57	38	17	1.62	68	50
4	1.13	19	1.57	38	0	1.63	68	50
5	1	19	1.57	30	17	1.63	72	50
6	1.13	25	1.55	30	17	1.63	68	50
7	1.13	19	1.55	38	17	1.62	72	50

Each ball group was tested for launch angle, spin rate and initial velocity under long shot (*i.e.*, driver) and short shot (*i.e.*, wedge and short iron) conditions. The test results were compared with tested values for commercially available golf balls, including the Pinnacle Gold LS and the Tour Balata. The Pinnacle Gold LS is well-known by those skilled in the art to have low-spin, long distance performance characteristics, whereas the Tour Balata is widely recognized as a high spin, short shot ball.

Two pairs of tests were established for analyzing long shot and short shot performance of each ball. For spin testing under long shot conditions, one test, identified below as “Standard Driver”, was based upon USGA parameters for distance testing using a Pinnacle Gold LS ball. The “Standard Driver” test is designed to reflect the driving conditions imparted on the ball by a professional tour player. In particular, calibration of parameters for the “Standard Driver” test are that a Pinnacle Gold LS ball has a launch angle of 9 degrees, a spin rate of 3000 rpm and an initial velocity of 160 mph. After calibration, the balls are tested and compared to the performance of the Pinnacle Gold LS. The test results for the “Standard Driver” test were as follows:

SPIN TEST RESULTS: STANDARD DRIVER			
Ball Type	Launch Angle (degrees)	Ball Spin (rpm)	Initial Velocity (mph)
Pinnacle Gold LS	9.4	3018	160.1
Tour Balata	8.4	4292	158.7
Test Group #1	9.2	3096	159.0
Test Group #2	9.1	3116	157.0
Test Group #3	8.9	3246	160.1
Test Group #4	9.2	2981	159.7
Test Group #5	9.1	3371	157.3
Test Group #6	9.1	3065	158.7
Test Group #7	9.0	3130	157.5

The second test for long shot performance, identified below as “Average Driver”, is designed to reflect the driving conditions imparted on the ball by a recreational player. Specifically, calibration of parameters for the “Average Driver” test are that a Pinnacle Gold LS ball have a launch angle of 10.5 degrees, a spin rate of 3600 rpm and an initial velocity of 140 mph. After calibration, the balls are tested and compared to the performance of the Pinnacle Gold LS. The test results for the “Average Driver” test were as follows:

SPIN TEST RESULTS: AVERAGE DRIVER			
Ball Type	Launch Angle (degrees)	Ball Spin (rpm)	Initial Velocity (mph)
Pinnacle Gold LS	10.3	3545	140
Tour Balata	8.8	4852	138.6
Test Group #1	9.8	3672	139.3
Test Group #2	9.8	3536	137.9
Test Group #3	9.8	3923	139.9
Test Group #4	10.2	3482	139.1
Test Group #5	9.9	3797	137.8
Test Group #6	10.1	3572	138.9
Test Group #7	9.9	3611	137.8

One test for simulating short shot conditions, identified below as “Standard 8 Iron”, is designed to reflect tour player performance using an 8 iron. Specifically, calibration of parameters for the “Standard 8 Iron” test are that a Tour Balata ball have a launch angle of 18 degrees, a spin rate of 9000 rpm and an initial velocity of 115 mph. After calibration, the balls are tested and compared to the performance of the Tour Balata. The test results for the “Standard 8 Iron” test were as follows:

SPIN TEST RESULTS: STANDARD 8 IRON

Ball Type	Launch Angle (degrees)	Spin (rpm)	Initial Velocity (mph)
Pinnacle Gold LS	19.1	7892	116.1
Tour Balata	18.1	9051	114.4
Test Group #1	19.8	7129	115.4
Test Group #2	20.1	6856	115.2
Test Group #3	19.0	7993	115.7
Test Group #4	20.1	6692	115.7
Test Group #5	19.2	7721	114.9
Test Group #6	19.9	7042	115.4
Test Group #7	20.2	6667	115.5

A second test for simulating short shot conditions, identified below as “Half Wedge”, is designed to reflect tour player performance using an half wedge. Specifically, calibration of parameters for the “Half Wedge” test are that a Tour Balata ball have a launch angle of 30 degrees, a spin rate of 7000 rpm and an initial velocity of 52 mph. After calibration, the balls are tested and compared to the performance of the Tour Balata. The test results for the “Half Wedge” test were as follows:

SPIN TEST RESULTS: HALF WEDGE

Ball Type	Launch Angle (degrees)	Ball Spin (rpm)	Initial Velocity (mph)
Pinnacle Gold LS	33.8	5244	52.4
Tour Balata	30.5	7142	51.6
Test Group #1	30.9	6413	51.9
Test Group #2	31.1	6259	52.4
Test Group #3	29.8	6811	52.1
Test Group #4	31.1	6314	52.4
Test Group #5	30.7	6538	52.5
Test Group #6	30.6	6380	52.5
Test Group #7	31.3	6168	52.3